Numerical modeling of heat transfer and fluid flow in rotor-stator cavities with throughflow

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The present study considers the numerical modeling of the turbulent flow in a rotor-stator cavity subjected to a superimposed throughflow with heat transfer. Numerical predictions based on one-point statistical modeling using a low Reynolds number second-order full stress transport closure (RSM) are compared with experimental data available in the literature. Considering small temperature differences, density variations can be here neglected which leads to dissociate the dynamical flow field from the heat transfer process. The turbulent flux is approximated by a gradient hypothesis with tensorial eddy diffusivity coefficient.

The fluid flow in an enclosed cavity with axial throughflow is well predicted compared to the velocity measurements performed at IRPHE [1] under isothermal conditions. When the shroud is heated, the effects of rotation Re and coolant outward throughflow C_w on the heat transfer have been investigated and the numerical results are found to be in good agreement with the data of Sparrow and Goldstein [2]. We have also considered the case of an open rotor-stator cavity with a radial inward throughflow and heat transfer along the stator, which corresponds to the experiment of Djaoui et *al.* [3]. Our results have been compared to both their temperature measurements and their asymptotic model with a close agreement between the different approaches (figure 1(a)). All the comparisons have been extended for a wide range of the Prandtl number Pr (figure 1(b)). The predictions can be correlated by the empirical correlation law: $Nu_{av} = 0.0044 \;\; Re^{0.8} \;\; (1000 + C_w)^{0.11} \;\; Pr^{0.5}$.

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[1] Poncet *et al.*, *Phys. Fluids* **17 (7)** (2005).

[2] Sparrow and Goldstein, *J. Heat Transfer* **98**, 387 (1976).

[3] Djaoui *et al.*, *Eur. J. Mech. B - Fluids* **20**, 371 (2001).

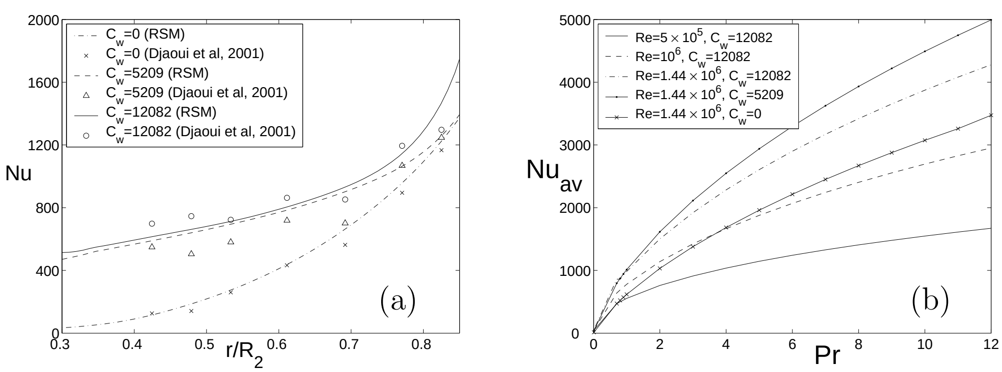

Figure 1: (a) Radial evolution of the local Nusselt number Nu for $Re = 1.44 \times 10^6$, $Pr = 0.7$ and three coolant flowrates. (b) Effect of the Prandtl number on the averaged Nusselt number Nu_{av} for five flow conditions (stator heated).